Total aortic arch replacement in 2013: where do we go from here?

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In the last 10–15 years, substantial progress has been made in the surgical treatment of patients who require open repair or replacement of the aortic arch. A number of technological advances have contributed to the improved outcomes. These include better methods of brain and myocardial protection, improved cardiopulmonary bypass circuits, impregnated polyester grafts, use of biological glues, and better identification and management of coagulopathies. Enhanced understanding of the pathophysiology and limitations of hypothermic circulatory arrest has also played a major role in the improved results. Using a variety of techniques, highly satisfactory outcomes have been achieved for patients who require partial (hemi-arch) repair, which requires relatively short periods of circulatory arrest. Total arch replacement has traditionally been associated with higher risks. However, recent reports on total arch replacement from experienced centers document operative mortality rates and stroke rates <10% for both outcomes [1–6]. These studies have included, to a variable extent, patients with acute aortic dissection who required emergent operation (2.4–19% prevalence), and it is well recognized that early mortality and morbidity are increased in this subset of patients. Some form of antegrade cerebral perfusion for brain protection was used for all of the patients in these studies, and there is emerging consensus that this represents the optimal method for brain protection. Spinal-cord ischaemic injury, in the absence of extensive resection of the descending thoracic aorta, has occurred rarely.

With the advent of endovascular stent-grafting of the thoracic aorta, alternative methods for management of disorders, involving the aortic arch, have been explored. Hybrid procedures have been developed that consist of transposition of the brachiocephalic arteries, followed by synchronous or metachronous stent-grafting of the aortic arch and adjacent descending thoracic aorta with either an antegrade or retrograde approach. It was hypothesized that this technique would be a safer, less-extensive procedure with less mortality and morbidity than conventional open repair and would be particularly applicable to ‘high-risk’ patients (i.e. those considered to be at substantial risk or non-candidates for open repair).

How successful have these hybrid procedures been in achieving these objectives? It is important to note that hybrid procedures are less-well standardized than open procedures, with considerable variability in the technique from centre to centre and even within individual centres. Debranching has been performed in an extra-anatomical fashion in the cervical region with or without the use of synthetic grafts. Using a sternotomy, combinations of branched grafts from the ascending aorta to a variable number of the aortic branches have been employed, with or without the use of cardiopulmonary bypass or hypothermic circulatory arrest. The stent grafts have been deployed in an antegrade direction from the ascending aorta, or in a retrograde direction from a peripheral artery, either at the time of debranching or at a subsequent procedure.

Recently conducted meta-analyses of hybrid procedures have reported stroke and mortality rates that do not differ substantially from those reported for conventional open repair. Koullias and Wheatley evaluated hybrid aortic procedures from publications through May 2008 [7]. The data from 463 patients were analysed. Overall 30-day mortality was 8.3%. The rates of stroke and paraplegia were 4.4 and 3.9%, respectively. Endoleaks were present in 9.2% of patients. The mortality, stroke and paraplegia rates were all higher among the patients in whom the procedures were performed with cardiopulmonary bypass than among those in whom cardiopulmonary bypass was not used, although the differences did not reach statistical significance. Endoleaks were significantly more frequent among the patients in whom cardiopulmonary bypass was not used. Long-term outcomes were not analysed.

Cao et al. [8] analysed 1886 patients from 50 publications of hybrid procedures. Patients with acute or chronic dissection, elective or emergency repair, high risk or average risk and in whom debranching, stented elephant trunk, or frozen elephant trunk, procedures were performed were included. For the entire cohort, the pooled early mortality, stroke and spinal-cord ischaemic event rates were 10.8, 6.9 and 6.8%, respectively. For the debranching group, these event rates were 11.9, 7.3 and 4.3%, respectively. The authors observed substantial heterogeneity in the techniques employed and lack of standardization in reporting specific patient data and endpoints.

To date, no randomized trials or large retrospective or prospective observational studies comparing hybrid procedures with conventional open repair have been performed. Benedetto et al. identified four observational comparative studies that included 378 patients (269 with open total arch replacement and 109 with hybrid endovascular aortic repair) [9]. All four studies reported data regarding mortality and neurological deficits, but none for late mortality or need for reintervention. Follow-up
extended to 18.5 months. Analysis of operative outcomes indicated that hybrid procedures did not significantly improve operative mortality (odds ratio 0.67; 95% confidence interval [CI] 0.27–1.63; \( P = 0.92 \)). They were associated with a slight, non-significant increase in permanent neurological deficits (odds ratio 1.93; 95% CI 0.86–4.37 \( P = 0.1 \)). No heterogeneity was observed among the outcomes of interest, and no publication bias was detected.

The available information, to date, with its well-documented limitations, demonstrates no beneficial effect of hybrid procedures over conventional open repair with respect to early mortality and stroke. Although hybrid procedures have been employed more frequently in 'high-risk' patients in several comparative series [10, 11], there is insufficient evidence from the published series of hybrid procedures to conclude that the majority of patients would not have been suitable candidates for open repair. It is of interest that, in five series of 'high-risk' patients (variably defined as 'high risk', American Society of Anesthesiologists [ASA] class ≥3 or reoperation, 'sub-optimal' for open repair, substantial cardiovascular comorbidity or mean logistic EuroSCORE of 31.1), early mortality rates ranged from 14.9 to 23.7%, and stroke rates from 4.6 to 13.6% [10–14].

Of greater concern, however, is the higher prevalence of spinal-cord ischaemic injury among patients treated with a hybrid procedure, and this may well represent the Achilles’ heel of the procedure. This complication has been rarely reported after conventional open-arch replacement when the amount of aorta replaced does not extend beyond the very proximal descending thoracic aorta, and the left subclavian artery is not sacrificed. No spinal-cord ischaemic injury was reported from four of the largest series of patients undergoing elephant trunk procedures in combination with total arch replacement in which the elephant trunk was an unstented, free-floating polyester graft [15–18]. Of interest, in the review by Cao et al. of patients in whom stented or frozen elephant trunk procedures were used (other forms of hybrid procedures), the rates of spinal-cord ischaemic injury were 7.9 and 7.2%, respectively [8].

Retrograde aortic dissection, particularly when the endograft is positioned proximally in the native ascending native aorta (Zone 0), is also a concern with hybrid procedures [19, 20]. In a recent study by Andersen and colleagues, retrograde type A dissection occurred in 3 (11%) of 27 patients in whom the endograft was anchored proximally in the ascending aorta [20]. Endograft placement in the native ascending aorta was the only predictor of 30-day in-hospital mortality in this study.

Reintervention rates appear to be higher for hybrid procedures, although these rates for patients who have undergone conventional open-arch replacement are infrequently reported. Endoleaks occur not infrequently with hybrid procedures, and the prevalence has ranged from 7.4 to 29% in the early follow-up interval in recently reported series [11, 19–21]. The majority are type I or type II endoleaks, and not all of them have required reintervention. A few reports of hybrid procedures have provided information on mid- or long-term follow-up or on the frequency of reintervention. In the study of Lee et al. [21] where the follow-up extended to 12 months, reoperation was required in 7 (26%) of 27 patients in that time interval, and 3 of these procedures were interventions for endoleaks.

On the basis of currently available information, there is no evidence to state with certainty that hybrid procedures offer distinct advantages over open total arch replacement. It appears unlikely that large randomized trials comparing the two forms of therapy will ever be conducted. It is also unlikely that comparative studies from individual centres will provide the sufficient numbers of patients to permit meaningful conclusions, because of the relative infrequency with which these procedures are performed and the preferences and biases that may exist in individual centres. What is needed is a registry to accrue sufficient numbers of patients to permit valid comparisons. In such a registry, precise definitions of 'high risk', 'unsuitability for open repair' and other subjective variables will be essential. The use of EuroSCORE, Society of Thoracic Surgery Database Risk Models or the ASA risk score may be of value in this regard. Standardized reporting of various techniques for performing hybrid and open operations will also be necessary. Conditions, such as acute type A or type B aortic dissection, should be analysed separately because of the higher early mortality and morbidity associated with early repair. Follow-up information regarding the frequency of reoperations after open and hybrid repair, the frequency of endoleaks in the hybrid group, survival and cumulative costs for both procedures should also be obtained.

Until sufficient data are accumulated to perform the necessary analyses, the question of whether hybrid procedures are as good, or better than, open ones for total repair of the aortic arch will remain unanswered.

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**REFERENCES**


